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EDITORIAL

DISEASES OF CATTLE

ESTIMATES of the incidence of disease in cattle are made from time to time, and are quoted in various publications. From the incidence, calculations are made of the probable loss to the country in meat and milk, and to the farmer in terms of finance. Without more accurate knowledge of the extent of the different diseases any estimate must be quite inaccurate: it has to be accepted, however, that the losses are high. Concerning some of the prevalent diseases of cattle, research work has progressed to an extent whereby the causes and the various factors associated with them are understood, and methods of control are now being practised. In bovine mastitis, for example, the association of micro-organisms with the disease has led to control by the use of bactericidal agents, injected into the udder through the teat canal, together with the adoption of methods of husbandry which reduce to a minimum the chances of transmitting further infection. Brucellosis is now being well controlled by the setting up of resistance to infection through the medium of attenuated strains of *Br. abortus* as vaccines. Tuberculosis has been the subject of control by building up herds free from infection, following the diagnosis of the disease by the use of the tuberculin test. These are three examples: there are many others which could be mentioned.

The evolving of control methods represents the results of much work and study in which veterinarians have played, and continue to play, the essential part. Not only are we intimately concerned in the laboratory aspects of this work, we are entirely responsible for the necessary field trials and for the subsequent application of the techniques in practice.

An important result of the controlling of recognised disease in cattle, in addition to the prevention of losses from the condition being dealt with, is the showing of other causes giving rise to somewhat similar symptoms. An outstanding example concerns brucellosis. Now that we are able to control infec-

tion due to *Br. abortus,* our attention can be focused on causes of abortion in cattle other than that caused by brucellosis. We have always realised that abortions occurred in the absence of brucella infection, although we may not have realised the extent to which it existed. From recent results it would appear that abortion associated with causes other than *Br. abortus* infection may be quite extensive: efforts must now be concentrated on the recognition of such factors. Again, the use of improved types of tuberculin and the adoption of tuberculins prepared from different acid-fast bacilli have shown the different causes of sensitisation to tuberculin and the methods of recognising true bovine tuberculous infection.

As research work continues, new findings are made. In this issue of the *British Veterinary Journal* an article deals with a disease in cattle, the existence of which does not seem to have been previously recognised. We refer to "tick-borne fever" in this country. The disease is well known in sheep, and much credit is due to those who first recognised it in that animal as a condition quite apart from louping-ill. The occurrence of this disease in cattle may explain some of the conditions which have puzzled clinicians in some areas throughout the country. It opens up a new field of research, not only concerning the incidence of the condition and its relationship to other diseases, but also for the devising of methods of control. The results of the research work leading to the recognition of "tick-borne fever" in cattle is a further example of the application of general scientific discovery and knowledge to the problems of animal health and disease. Those concerned with investigation into these problems must always be familiar with the latest work in many branches of science. We may be apt to think that animal health and disease can be dealt with entirely along certain fixed lines: every day we recognise that such a policy is impossible. Almost every branch of science has something to contribute to our work, and it is our duty to make every use of the findings of our colleagues in the world of science in order that full advantage may be taken of all recent developments, and we will make use of whatever discoveries can be successfully applied in practice to the maintenance of healthy livestock and the prevention and cure of diseases in our domestic animals.

GENERAL ARTICLES

THE RECOGNITION OF TICK-BORNE FEVER AS A DISEASE OF CATTLE

By J. RICHARD HUDSON

TICK-BORNE fever of sheep was first described in 1932 by workers at the Moredun Institute (Gordon, Brownlee, Wilson and MacLeod), in Scotland. During 1948, in the course of investigations into respiratory diseases of cattle, attention was drawn to a mild, febrile disease of cattle on a farm in Somerset. This condition was characterised, in animals in the milk herd, by a sudden fall in milk yield, a temperature reaction lasting one to five days, and a tendency to lag behind in the herd when brought in for milking. Some of the affected animals were reported to have coughed during the course of the disease; but coughing was not a constant symptom. Cases were at first treated with one of the sulphonamide group of drugs; but treatment was discontinued when it was found that it had little effect on the course of the disease, and when it was realised that, in untreated cases, the temperature soon became normal, and that, unless the animal was in a late stage of lactation, the milk yield returned.

Blood, in citrate, from a typical case of the disease was forwarded to the laboratory, where it was inoculated into two cattle. A short temperature reaction was produced, beginning on the seventh and eighth days, and lasting 24 to 48 hours, respectively. Passages were made with blood taken during the temperature reaction or on the day after the temperature had fallen. After two passages, preliminary experiments were made to determine the nature of the infective agent. These experiments indicated that the agent was concentrated in the deposit from centrifuged, citrated blood, and that it was adversely affected when the cells in the deposit were lysed by distilled water. This suggested that the causal agent was an organised parasite, rather than a true virus, and blood smears stained with Giemsa were carefully examined. Previous examinations had shown the absence of piroplasms. Bodies resembling tick-borne fever bodies (McEwen, 1947) were found, and Dr. Gordon and Mr. Brownlee confirmed that they were identical with the bodies found in the blood of affected sheep in Scotland. A sheep strain of the disease was obtained from Moredun, through the kindness of Dr. A. Foggie, and the results of cross-immunity experiments are recorded below.

Symptoms

During the course of experiments at Weybridge, some 54 cattle have been inoculated with the Somerset strain. These have included heifers, cows, steers, young bulls, and calves. The incubation period, following inoculation of citrated blood, has varied from four to eleven days. In slightly over 50 per cent of animals it has been either six or seven days. Following the incubation period, the temperature rises sharply to 104 degrees, 105 degrees F., or even higher, and remains elevated for two to eight days. In 63 per cent of animals the duration of the temperature reaction has been either three or four days.

If the temperature persists for more than two days it falls gradually, and in about 75 per cent of cases the primary reaction is followed by a second and, rarely, by later peaks of shorter duration. The experimental evidence suggests that when, over several passages, blood is drawn during the temperature reaction and inoculated immediately, reactions become more marked; but that blood stored in the refrigerator for several days produces a less marked thermal response.

In twelve cattle inoculated with the Moredun (sheep) strain, the incubation period has varied between four and eleven days: in 67 per cent of animals it has been either seven or eight days. The duration of the reaction has been two to six days: in 67 per cent either four or five days. The difference between the mean incubation periods of the two strains is less than one day, and between the mean duration of the thermal reactions less than half a day. In view of the small number of cattle inoculated, the similarity between the strains is therefore rather striking.

Whilst the temperature is elevated, animals show an increase in the respiratory rate. Counts of over 100 per minute have been made in heifers with a temperature of 106 degrees or over; but a rate of 80-90 per minute is more usual. No cows in milk have been inoculated. However, the fall in yield was the symptom leading to the detection of the disease on the farm.

Affected cattle show a tendency to droop the ears, and appear somewhat dull; but the lack of general symptoms in an animal with a high temperature is a character of the disease. It is surprising to find an animal with a temperature of 105 degrees F. contentedly chewing its cud. One expects a high temperature over several days to produce constipation; the fæces are almost always of normal consistency. A few animals have started to scour during the reaction: scouring has continued, and investigation of such cases has led to the finding of Johne's bacilli. There are no discharges from the eyes or nose; as a rule the muzzle is normally dewy, and coughing has been so occasional that there seems no reason to attribute it to the disease itself. There is no evidence to suggest that the disease produces abortion in pregnant cows and heifers; but no pregnant animals have been inoculated, and insufficient is known of the natural disease to assert that abortions do not occur. In experimental ewes that have been inoculated with the ovine strain in the last weeks of pregnancy, abortions have occurred.

Pathology

No deaths have occurred amongst inoculated animals, but two cattle have been killed in order to see what pathological changes are produced. Apart from a little swelling of the spleen, due to slight enlargement of the Malpighian corpuscles, no macroscopic lesions have been found.

Sections of liver, kidney, spleen, lungs, lymphatic glands, pancreas, adrenals and abomasum have been studied microscopically. In some areas of the liver of both animals the Kupffer nuclei appear slightly swollen and more prominent than in normal liver, and one animal shows slight, cloudy swelling of the hepatic cells. Patches of mild, cloudy swelling are also present in the convoluted tubules

of the kidneys, and some of the Bowman's capsules in affected areas contain traces of hyaline material. The medulla shows a little congestion; but neither miscroscopically nor macroscopically do the changes justify description as catarrhal or glomerular nephritis. No lesions attributable to the disease are present in the lungs, pancreas, adrenals or abomasum.

The spleen and lymphatic glands show, in sections from both animals, an appearance suggesting that the lymphoid tissue has suddenly been "drained" of many of the lymphocytes usually present. The cuffs around the reaction centres are less dense, and frequently narrower than normal. The pulp of the spleen appears as if there is a little œdematous fluid spacing the elements between the sinusoids. The sinuses of the lymphatic glands are dilated with fluid and contain lymphocytes of normal appearance, together with an unusually large number of large, round cells.

In general, therefore, only rather indefinite changes are to be found in the organs. Gordon, *et al.* (1932), report that in sheep killed for examination the only pathological change found is splenic enlargement.

The most important pathological changes are apparently to be found in the blood. Chart 1 illustrates the total white cell counts of three animals during the course of the infection. Each animal shows a fall in the count at about the time of the reaction, followed by a rise to a figure higher than normal, which persists for ten days or more. In each case there is, in addition, a sharp peak, most marked in heifer 1519, where the count reached 23,500 cells/mm. Perusal of the differential counts (Table 1) shows that these peaks are not due to the sudden increase of any single cell-type. In a fourth animal several such peaks occurred; they were more marked, and they coincided with attacks of diarrhœa. They are therefore, in all probability, attributable, in part at least, to changes in general composition of the blood.

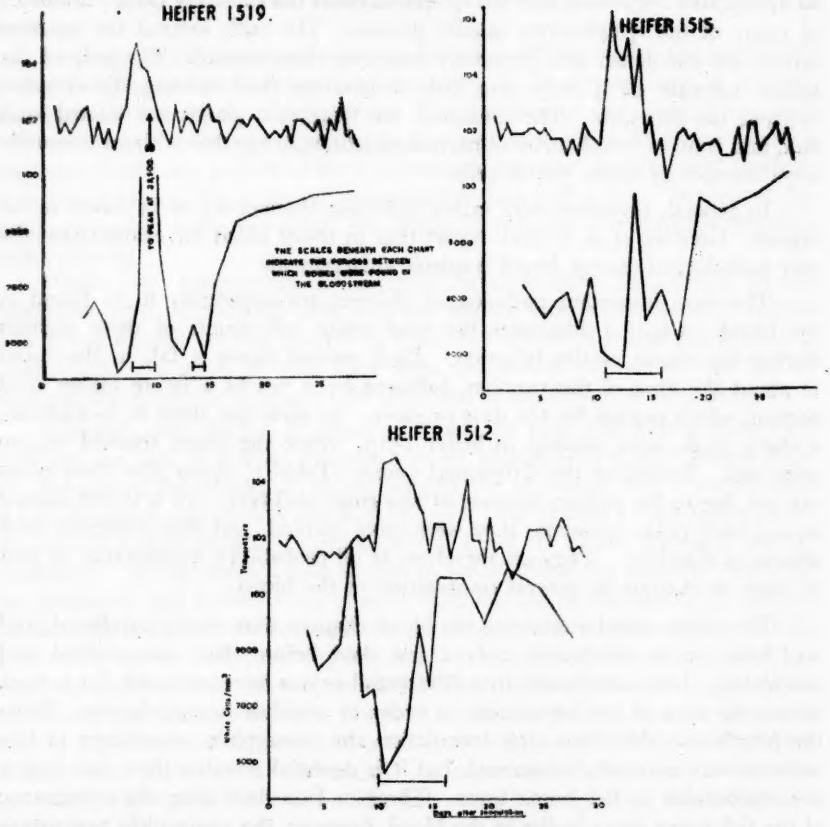
The cattle used for studying the blood changes were newly-purchased, and had been at the laboratory only a few days before they were stabled and inoculated. It is unfortunate that differential counts were not made for a week before the start of the experiment in order to establish normal figures. From the fourth to eighth days after inoculation the neutrophile percentages in two animals were markedly subnormal, but it is doubtful whether these low figures are attributable to tick-borne fever. Three or four days after the appearance of the tick-borne fever bodies in the blood, however, the neutrophile percentage drops in all the animals and a rise of monocytes occurs. The lowest figure for neutrophiles in these three animals is 2.25 per cent; but, in isolated counts in other animals, lower figures have been obtained. In one animal a smear of "buffy coat" from centrifuged blood showed no granulocytes in 400 white cells counted.

The fall in neutrophiles is accompanied by an increased proportion of cells with unlobed nuclei and ribbon-nucleated cells. More primitive meta-myelocytes are rare. The appearance of the cells, particularly the tendency to swelling and fraying of the nuclei, suggests that the granular leucocytes are

undergoing a pathological change in the blood. This may, or may not, be due to their actual parasitism by *Rickettsia*.

Although their nuclei are often rather more pachychromatic than usual, and, when stained supravitally, their neutral red granules form a rather large and extensive rosette, the monocytes that appear in increased numbers in the

CHART I.



blood are monocytes *sensu strictu*. Cells with scattered neutral red granules are very rare indeed, and no oxydase-positive cells, other than those of the granulocyte series, have been encountered.

Aetiology

The causal organism is to be seen in the granulocytes, metamyelocytes and monocytes of the blood during and for a few days after the temperature reaction (Figures 1-3). It reappears in numbers sufficient to be detectable on microscopic examination, during the second and later peaks if these occur. The bodies vary in appearance, suggesting a multiplication-cycle in the cells. The

simplest forms consist of a round, or slightly oval, dot of a slate-blue colour when stained by Giemsa. Larger bodies appear of a somewhat rounded, irregular shape, and may measure as much as 4.5 x 3.5 μ. Such larger bodies have indefinite, more darkly-stained areas, a deeper shade of the same general colour. Other forms appear to result from the fragmentation of larger bodies and consist of collections of coccoid elements 0.3-0.4 μ in diameter. The number of such elements in a group is very variable. It is not uncommon to find more than one body in a cell, and frequently, but not constantly, all the bodies in one cell are of approximately equal size and of the same type. In some cells the bodies are surrounded by a rather indefinite halo; but such haloes are rare, and never as clear as the halo around *Rickettsia ruminantium* Cowdry, the causal agent of heart-water. The bodies are oxydase negative, and in supravitally-stained preparations segregate neutral red.

The bodies rsemble very closely *Rickettsia canis,* Donatien and Lestoquard (1935), and from the descriptions appear to be similar to *Rickettsia bovis* Donatien and Lestoquard (1936) and *Rickettsia ovina* Lestoquard and Donatien (1936). There can be no doubt that they are *Rickettsia.* The last three, named, species have not been reported in cells other than monocytes. *Rickettsia ruminantium* is found in the endothelial cells of the capillaries, and, clinically and pathologically, heart-water is readily distinguishable from tick-borne fever. It would be unwise, however, to give a specific name to the causal agent of tick-borne fever until a careful comparison has been made with *R. bovis* and *R. ovina,* and, if possible, cross-immunity experiments between the three conditions should be made.

In vitro, citrated, infected blood may be stored at a temperature of +4 degrees to +8 degrees C. for periods up to 14 days. Blood stored for 28 days, on one occasion, has infected; the incubation period was prolonged to 17 days; but a good reaction followed. No reactions have occurred when blood kept for more than a month has been used. Blood usually retains its infectivity for 48 hours at room temperature, and the causal agent is not destroyed by considerable growth of anthracoid contaminants.

Attempts to propagate the *Rickettsia* in developing hen eggs have been unsuccessful. In two experiments, serial passages on the chorio-allantois has been attempted. In each experiment, ten eight-to-ten-day-old embryos were inoculated and half the eggs were incubated at 35 degrees C. and half at 30 degrees C. for three or four days. After two passages an emulsion of pooled membranes was inoculated to two cattle. There was no reaction, and the cattle gave good reactions on subsequent immunity test.

Two similar attempts to passage the *Rickettsia* in the yolk-sac of seven-to-eight-day embryos have been made. Half the inoculated eggs were incubated at 35 degrees C. and half at 30 degrees C. for three or four days. After two and three passages, respectively, emulsion of yolk-sac was tested by intravenous inoculation into steers. In the first experiment one of the steers inoculated gave a suspicious reaction and failed to react to a subsequent test. Blood collected during this suspicious reaction failed to infect two animals which later gave

excellent reactions on test. The other steer showed no reaction, and reacted well to a subsequent test inoculation with blood. In the second experiment, third passage yolk-sac wall was inoculated intravenously into two cattle. There was no suggestion of any thermal response, and the cattle reacted to an immunity test. No bodies resembling *Rickettsia* have been found in smears of yolk-sac material. Finally, an effort was made to propagate the organisms by the intravenous inoculation of twelve-to-thirteen-day embryos. The sheep strain was used for this experiment. Sub-inoculations were made with blood at three- and four-day intervals. After three passages in parallel at 35 degrees and 30 degrees C., blood from the embryos was inoculated intravenously to two sheep. From the eighth day both sheep showed a high temperature that persisted for about three weeks; but sub-inoculation to two further sheep failed, and, on test, all four animals reacted as severely as did the controls. Smears of the embryo blood showed no bodies suggesting *Rickettsia*.

Animals Susceptible

Yearling and adult cattle of both sexes, purchased in the Weybridge area, have been used in the majority of experiments, and it would appear that, provided that they are more than about nine months of age there is little difference in susceptibility. Similarly, there is no difference in susceptibility between the Jersey, Shorthorn, Red Poll and Ayrshire breeds. Calves, however, are less susceptible than older animals. The number of calves below six months of age inoculated has been small, but a high proportion failed to give a febrile reaction to blood proved infective to other cattle. The relative resistance of young animals to tick-borne diseases generally is well known. Young animals are less susceptible than adults to most piroplasmoses, to anaplasmosis, to the genuine virus disease, Nairobi sheep disease, and to the rickettsial disease, heart-water. McEwen (1947) found that, under natural conditions, tick-borne fever in lambs, during the first two weeks of life, was mild.

Sheep and goats are both susceptible to inoculation; but no febrile reaction or other signs of infection occur in guinea-pigs inoculated intraperitoneally, or in ferrets inoculated subcutaneously.

Two blind passages were made by intraperitoneal inoculation of male guinea-pigs. There was no scrotal reaction nor other evidence of infection. Mice survived intravenous inoculation.

Three attempts have been made to recover the infective agent from rabbits, using rabbits of different ages, bleeding about the fourteenth day, and inoculating back to cattle. In the first experiment, two young rabbits were bled on the thirteenth day after inoculation, and the blood inoculated intravenously to heifer 1556. No reaction occurred; but, on test, heifer 1556 failed to react to two doses of blood known to have been infective. In the second experiment, two old rabbits were used and were bled on the tenth day. The blood was inoculated to a heifer and a young bull. Neither of these reacted, and both proved susceptible to test doses of bovine blood, although the reaction in the heifer was very poor. The bull was bled 20 days after inoculation, and its

FIG. 1
Tick-borne fever bodies in neutrophile all. Groups of coccoid bodies.

FIG. 2
A large collection of coccoid bodies in a neutrophile that has been ruptured by pressure.

FIG 3
A large solid body in one eosinophile cell.

(Article by J. R. Hudson)

blood, on sub inoculation to a susceptible heifer, provoked no reaction. In the third experiment two old rabbits were used. These developed a morning temperature of 104.2 degrees on the ninth day after inoculation. No *Rickettsia* were found in smears, and blood collected on the twelfth day produced no reaction in susceptible heifer 1593. In this animal, too, the reaction to the test inoculation was poor compared with a control inoculated with the same blood, and compared with two animals of the same origin inoculated with different blood.

The infection produced in sheep by the bovine strain appears to be less virulent than that produced by the sheep strain. When part of a batch of sheep has been inoculated with the sheep, and the remainder with the bovine, strain, it has happened more than once that all those receiving the former, but not all those receiving the latter, have reacted. The temperature reactions to the bovine strain have been less than those to the ovine. No attempt has been made to passage the bovine strain rapidly in sheep, but two efforts to maintain a line in sheep, using blood stored for short periods in the refrigerator, have been unsuccessful. Although a directly comparable experiment, using blood stored for exactly similar periods, with the sheep strain in cattle has not been made, no difficulty has been experienced in passaging the sheep strain in cattle with blood stored in the refrigerator between passages. These results give the impression that the bovine strain is more closely adapted to cattle than the Scottish ovine strain is to sheep. The Scottish investigators have not recorded any experiments on the susceptibility of cattle. Thorshaug (1940) states that, in Norway, a heifer inoculated with sheep's blood failed to show a febrile reaction, but that blood taken from the heifer on the fifth day was infective to sheep. No difficulty has been experienced at Weybridge in provoking reactions in cattle by the inoculation of the sheep strain.

Transmission

No tick transmission experiments have been made in cattle. No cases of the disease occurred on the farm between the beginning of October, 1948, and the third week of April, 1949, when a case occurred a few days after ticks were first noticed on the cattle. Two engorged female ticks were sent to the laboratory and proved to be *Ixodes ricinus L.* It is hoped to infect larvæ obtained from these females.

Immunity

Gordon and his collaborators (1932) showed that, in sheep, an attack of tick-borne fever often did not confer complete protection against reinoculation with infective blood. Sheep frequently reacted thermally to a second inoculation, given a few days after the end of the first, and further inoculations might be followed by further reactions. As a rule, later reactions become progressively less severe, and eventually immunity appeared to be complete. Although thermal reactions to a third inoculation (within a short period of time) are rare, a similar experience has obtained in cattle inoculated with the bovine strain. The failure of one attack to give complete immunity has made difficult the designing of

CHART 2

IMMUNITY TEST OF CATTLE, USING SOMERSET STRAIN.

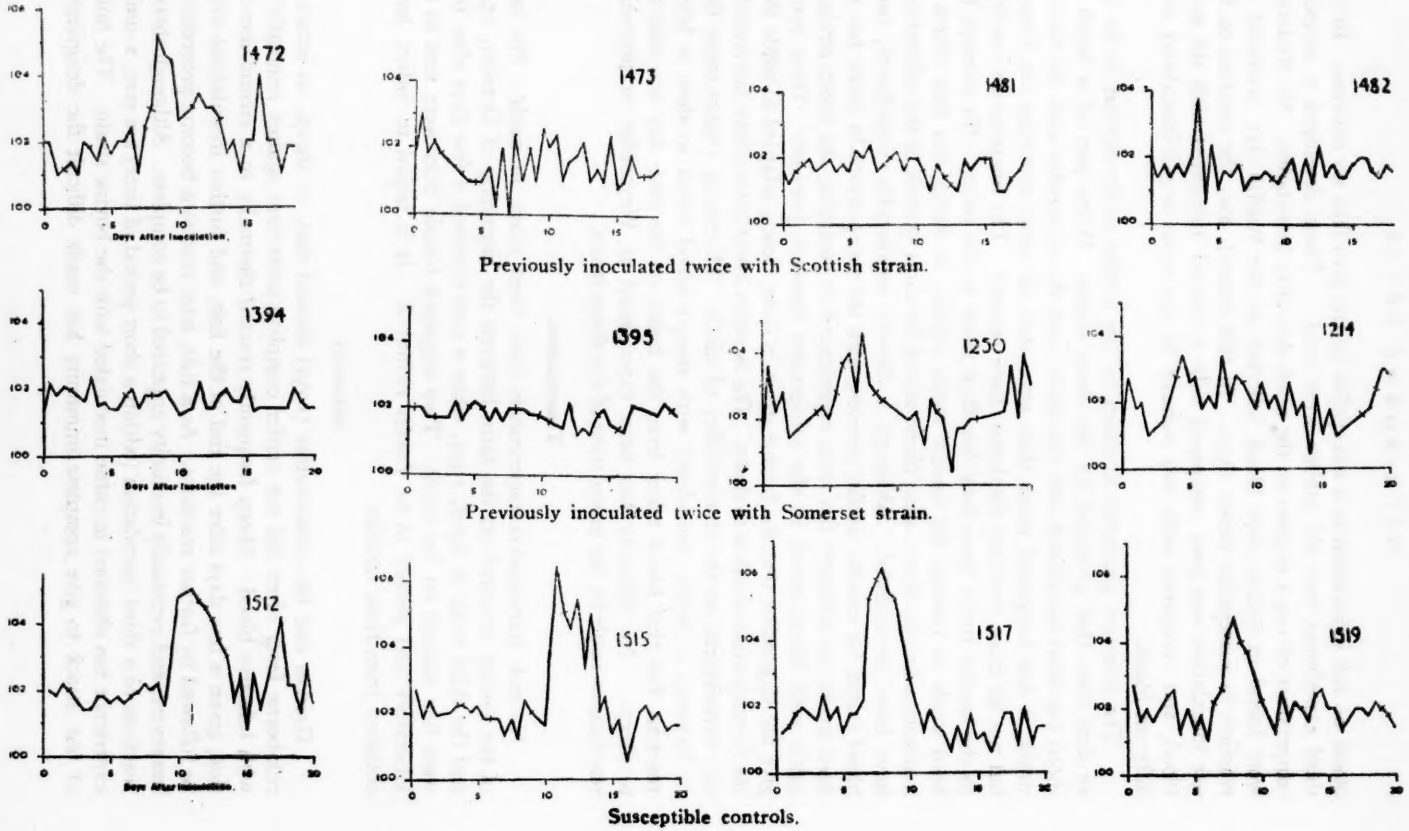
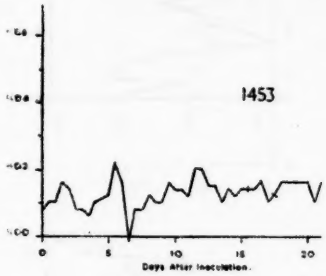
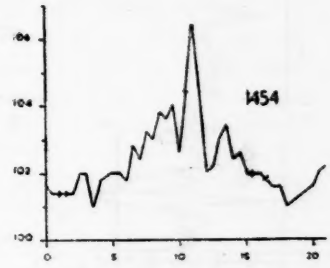


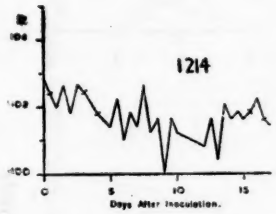
CHART 3

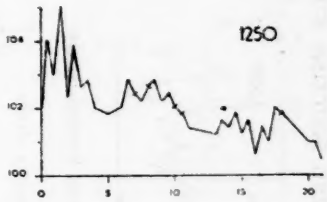
IMMUNITY TEST OF CATTLE, USING SCOTTISH STRAIN.



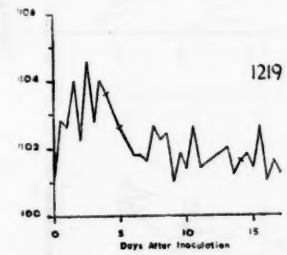


Previously inoculated twice with Scottish strain.

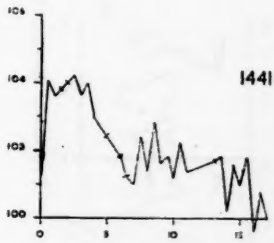




Previously inoculated three times with Somerset strain.



Previously inoculated once with Somerset strain.



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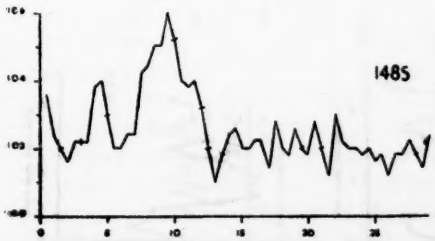
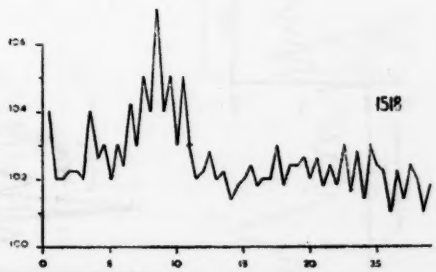
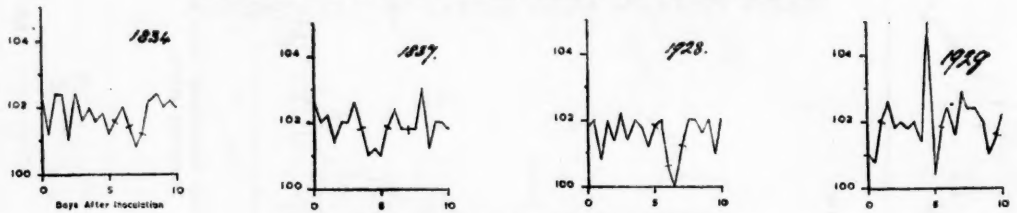




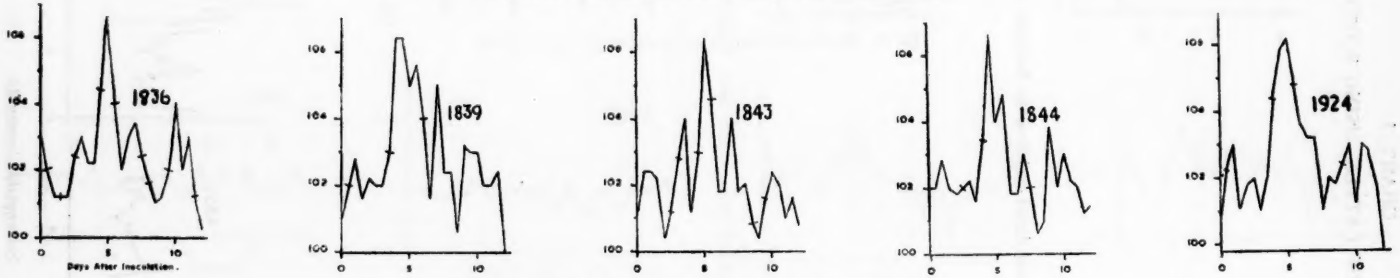
Susceptible controls.

CHART 4

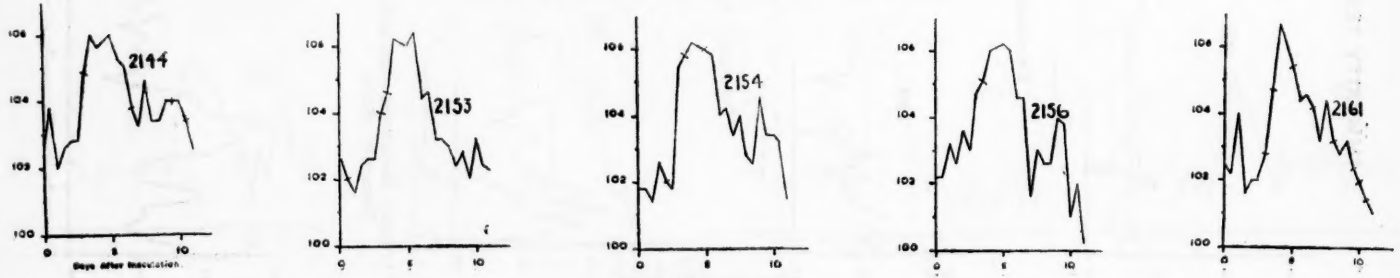
IMMUNITY TEST OF SHEEP, USING SCOTTISH STRAIN.



Previously inoculated twice with Scottish strain.



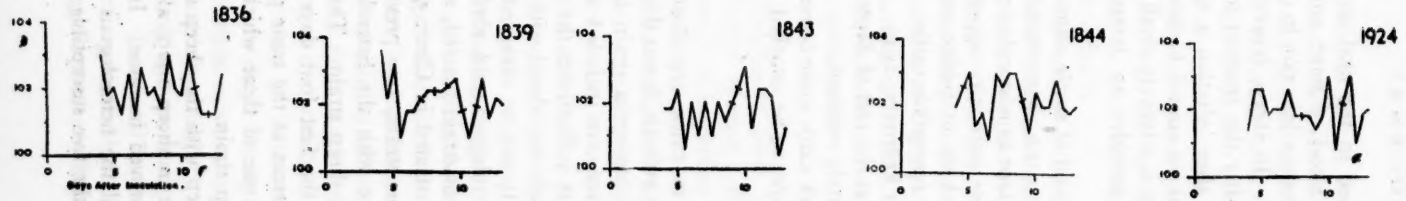
Previously inoculated twice with Somerset strain.



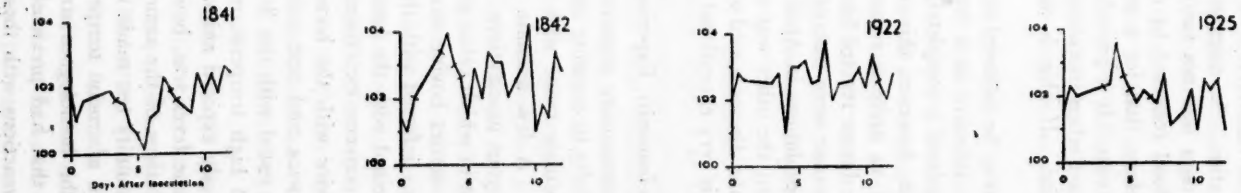
Susceptible controls.

CHART 5

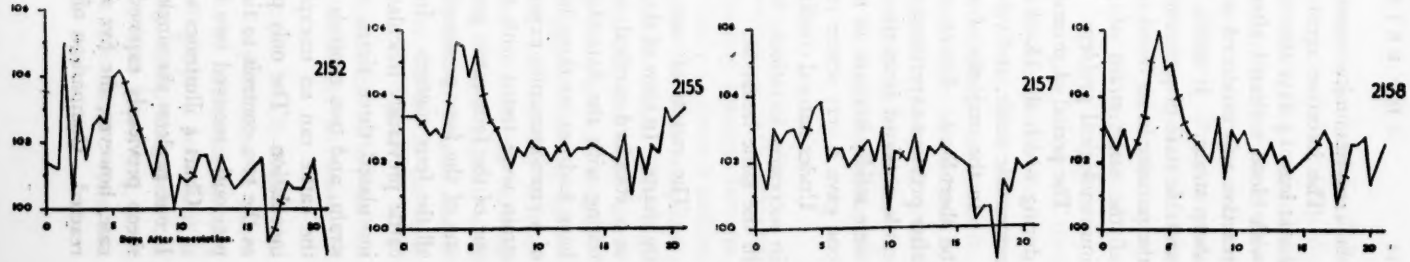
IMMUNITY TEST OF SHEEP, USING SOMERSET STRAIN.



Previously inoculated with Somerset strain.



Previously inoculated with Scottish strain.



Susceptible controls.

the cross-immunity experiments which will be described in the next section.

The infective agent can be recovered from the blood of some animals for at least 14 days after inoculation. An attempt to produce infection in cattle with blood collected after 54 days was not successful. In sheep, however, a reaction was produced with blood collected 54 days after the reaction to the sheep strain. It seems, therefore, that for a period after infection a rather unstable state of premunition exists. It is probable that an animal harbouring the parasite in its blood can react when inoculated with a relatively small dose of the same strain of parasite. If this is so, it provides an interesting immunological problem.

The period of premunity may be followed by a period of sterile immunity, during which the blood is not infective in a dose of 50 c.c. intravenously to susceptible cattle, and yet the animal is completely resistant to reinoculation.

In the majority of animals, however, this complete immunity appears to be short-lived. Eleven out of 14 animals reinoculated six to twelve months after previous experience of the disease reacted like fully susceptible cattle. Two cattle obtained from the one source were inoculated in February, 1949. Both were solidly immune to test inoculations in April, but at the end of September one gave a very severe reaction; the other was completely resistant.

Under natural conditions the disease is said to attack cattle quite commonly in successive lactations; but it is very exceptional for cows to be attacked twice in the same lactation.

Cross-immunity Experiments

The results of two cross-immunity experiments in cattle are illustrated by charts. In view of the difficulty in ensuring immune animals, it was decdied, as a standard method, to inoculate twice with the homologous strain before testing with the heterologous. A few animals, however, are included which have had one or three homologous inoculations. Chart 2 illustrates the result of a cross-immunity experiment in which cattle previously inoculated with each strain were tested with the Somerset bovine strain. It will be observed that one of the four cattle previously infected with the heterologous, and, similarly, one of the four previously infected with the homologous strain reacted, as did all the four controls. In the converse experiment, illustrated in Chart 3, two cattle previously inoculated twice with the homologous strain, two previously inoculated three times, one twice and one only once with the heterologous strain, and two controls were tested with the Scottish sheep strain. Three of the cattle ran an unexplained high temperature for the first four days after inoculation. The only previously exposed animal to react at the same period as the two controls to tick-borne fever was, however, one of those which had previously received two inoculations of the same sheep strain.

Chart 4 illustrates an immunity test made in sheep with the sheep strain. If one neglects the single high, afternoon temperature in sheep 1929, all four sheep previously exposed to the homologous strain proved immune. In this case, however, the five sheep that had previously had the heterologous strain reacted. Comparison of the reactions with those of the five susceptible sheep

shows clearly that in the latter they were considerably more prolonged. This experiment indicates that two inoculations of the bovine strain to sheep do not confer as good an immunity against the ovine strain as do two inoculations of the homologous strain. Nevertheless, the five sheep have gained some protection from their previous inoculations. Two attempts to make the converse sheep experiment have not been entirely successful: Chart 5 illustrates one. Reference has already been made to the difficulty of producing regular infections in sheep with the bovine strain, and the failure of some of the control sheep to react, or poor reactions in the controls, has made a true interpretation of the results difficult.

The results of these four experiments, nevertheless, leave no doubt that there is a considerable degree of cross-immunity between the two strains, and, taken with the other evidence, justify the identification of the cattle disease as tick-borne fever. It is clear that the two strains differ in their host adaptations, and a clearer picture of their immunological relationships might be obtained by experiments in a third species of animal or by serological methods. It would appear, however, that very detailed study of the immunological response in this disease will be necessary before any attempt can be made to distinguish strain differences.

Discussion

Tick-borne fever of cattle appears to be a disease of little practical significance in itself. With the extension of milk recording amongst farmers, however, it is important to know what conditions are likely to cause a sudden drop in milk yield. It is possible that, now that the disease has been recognised, it will be found in other parts of the country where ticks occur. The high temperature and rapid respirations may suggest pneumonia, and time, worry and drugs may be saved if a proper diagnosis is made from a blood smear.

The effect of the disease on the leucocyte picture suggests that the disease may complicate other infections by interfering with the normal defence mechanisms. In this connection, it may be recalled that several reacting animals started to scour, and Johne's bacilli were found. These animals were yearlings, and possibly would have started to show symptoms of Johne's disease even had they not been inoculated. They were, however, stabled at the time, and were animals from at least two different sources.

Two animals suffering from mild husk have been inoculated. They reacted well, but there was no evidence to suggest that their inoculation increased the severity of the husk infection.

It may be mentioned that, in view of Caminopetros' (1948) findings in Q fever, a single attempt has been made to produce a lung infection in calves by intranasal inoculation. Caminopetros has shown that by intranasal injection of blood containing Q fever *Rickettsia*, to sheep and goats, a bronchitis is produced, and, as a result, air-borne infections in contact sheep and goats can occur. Intranasal inoculation of calves with tick-borne fever blood had, however, the same result as an intravenous or subcutaneous inoculation: there was no suggestion of any bronchial or pulmonary symptom.

XUM

HEIFER 1512.

Days after inoculation	4	5	6	7	8	9	10	11	12	13	14	15	16	18	20	22	25	28
Total white cells (thousands) ...	9.85	8.48	8.88	9.3	12.8	7.43	7.7	4.7	5.49	6.0	9.97	7.8	11.7	11.65	10.0	12.0	11.3	9.47
Differential count—																		
Lymphocytes ...	88.5	82.0	82.3	86.0	79.7	72.75	68.75	63.0	68.25	80.0	83.25	93.25	86.75	90.75	73.75	81.5	76.25	70.5
Neutrophiles ...	5.0	9.5	7.0	4.5	12.4	21.25	25.25	29.5	24.25	9.75	6.5	2.25	9.25	6.0	20.25	14.75	21.0	25.5
Monocytes	5.0	7.5	8.0	7.0	7.3	4.0	4.0	5.75	4.0	8.5	9.75	4.5	4.0	3.25	6.0	3.25	2.25	3.25
Eosinophiles ...	1.0	1.0	2.0	1.5	0.3	1.0	2.0	2.75	3.0	1.5	0.25	0.0	0.0	0.0	0.0	0.5	0.5	0.5

HEIFER 1515.

Days after inoculation	4	5	6	7	8	9	10	11	12	13	14	15	16	18	20	22	25	28
Total white cells (thousands) ...	6.6	5.92	5.44	5.95	6.3	5.0	6.8	4.2	3.9	3.6	9.76	5.3	6.4	4.56	9.69	9.16	9.78	10.58
Differential count—																		
Lymphocytes ...	63.5	67.0	62.0	68.0	65.0	70.4	68.7	62.25	57.25	56.75	75.5	83.75	76.0	86.75	81.2	57.75	52.25	52.25
Neutrophiles ...	23.5	21.0	26.0	21.0	25.5	23.3	23.0	29.75	34.0	32.5	17.0	4.25	13.7	7.0	7.8	31.75	35.5	35.5
Monocytes	6.5	7.0	7.4	6.7	6.0	3.3	5.0	5.5	4.0	7.75	5.0	10.0	9.6	3.75	8.0	4.75	5.0	3.75
Eosinophiles ...	5.0	4.0	2.3	3.7	2.0	2.3	2.3	2.25	4.5	3.0	2.0	1.5	0.4	2.25	3.0	5.25	6.0	6.75

HEIFER 1519.

Days after inoculation	4	5	6	7	8	9	10	11	12	13	14	15	16	18	20	22	25	28
Total white cells (thousands) ...	6.0	6.58	5.78	4.0	4.43	7.43	23.5	8.2	5.25	4.6	5.7	4.5	7.2	9.4	9.7	9.84	10.3	10.5
Differential count—																		
Lymphocytes ...	74.0	86.0	83.5	81.5	74.75	72.75	81.5	78.5	80.0	77.75	83.0	88.75	86.3	70.25	77.0	82.0	68.75	83.25
Neutrophiles ...	18.0	7.5	7.0	8.5	16.0	21.25	7.75	10.25	8.5	12.25	11.5	7.5	7.3	24.0	15.25	12.0	22.75	13.5
Monocytes	7.3	6.0	8.0	7.5	6.5	4.0	10.0	9.5	10.0	8.75	3.25	3.0	5.0	3.25	3.75	2.75	6.5	2.0
Eosinophiles ...	0.7	0.0	1.0	2.0	2.5	1.0	0.75	1.25	1.5	1.0	1.75	0.5	1.4	2.25	4.0	2.75	1.5	0.75

TABLE 1.—Differential counts of heifers 1512, 1515 and 1519.

The heavy line under the figures in the first line of each chart indicates days on which bodies were found in the blood.

Immunity in tick-borne fever presents a most intriguing problem, and it is unfortunate that no small laboratory animal has, as yet, been found susceptible, so that this problem can receive the attention that it deserves. So far as has been ascertained, the story is similar, but by no means identical, with that of immunity in heartwater (Neitz, *et al.*, 1947). The two diseases are related in other ways: their *Rickettsia* are morphologically similar, they differ from the typhus *Rickettsia* in being relatively or completely non-pathogenic for rodents, and by failing to multiply in the yolk-sac. There is no doubt that the diseases belong to the same group.

Summary

A mild disease of cattle, characterised by a febrile reaction and a reduction in milk yield, and occurring on farms in Somerset, is shown to be tick-borne fever.

The causal organism of tick-borne fever is a *Rickettsia* very closely related, on morphological grounds, to *R. canis, R. bovis,* and *R. ovina.* These *Rickettsia* are all found in circulating white blood cells, and are allied to *R. ruminantium,* a parasite of the vascular endothelium, more closely than to other described species of the genus.

Although the disease is not, in itself, of much economic importance, its recognition has established the identity of one mild condition which upsets temporarily the milk yield of cattle. The possible importance of the disease in influencing the course of other infections is discussed briefly.

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THE SEASONALITY OF CALF BIRTHS IN ENGLAND AND WALES

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SINCE June, 1944, the quarterly returns of the Ministry of Agriculture and Fisheries give the monthly records of the births of calves. The examination of these monthly records for the three years 1945, 1946 and 1947 give some interesting results on the size of the annual calf crop, and the seasonality of the calvings in England and Wales.

TABLE I.

Annual numbers of calves born in England and Wales (1945-47) (*Ministry of Agriculture Quarterly Returns*).

	1945	1946	1947
England	2,596,981	2,664,458	2,541,977
Wales	411,984	428,135	393,898
England and Wales ...	3,008,965	3,092,593	2,935,873
Comparison	100	102	97

Table I gives an annual crop of approximately three million calves in England and Wales, with the 1947 figures about 3 per cent below those of 1945. It seems, from this and other records, that the calf crop in 1947 was probably affected by the poor harvesting conditions in 1946 and the extremely severe late winter in 1947. It is known from knackery records that the casualty rates in cows in March and April, 1947, were much higher than in previous years.

The Ministry of Food slaughter records show that nearly 45 per cent of the calf crop is sold for slaughter as veals and bobbies, whilst it is known that another 5-10 per cent die naturally in early life, so that only about 50 per cent of the annual calf crop is reared for herd replacements and directly for beef in approximately equal proportions.

Wales annually produces one calf per 6.1 acres, and England one calf per 8.4 acres of crops and grass.

The Monthly Percentage of Calf Births in England and Wales

The following graph gives the percentage monthly calf births in England and Wales for each of the three years 1945-47 (Fig. 1):—

The graphs show that in general the monthly percentages have remained fairly constant, and that there have been no major changes in the seasonability of the calvings during the three years. The pattern for England shows that the peak is higher in autumn (October) than in spring (March), whilst in Wales the reverse is true. There have been slight annual changes, and in England the autumn calvings (September-December) have increased by about 1 per cent per annum, and in Wales by about 2 per cent. In the Wales graph, in 1947 the autumn peak is slightly higher than the spring peak. In England the

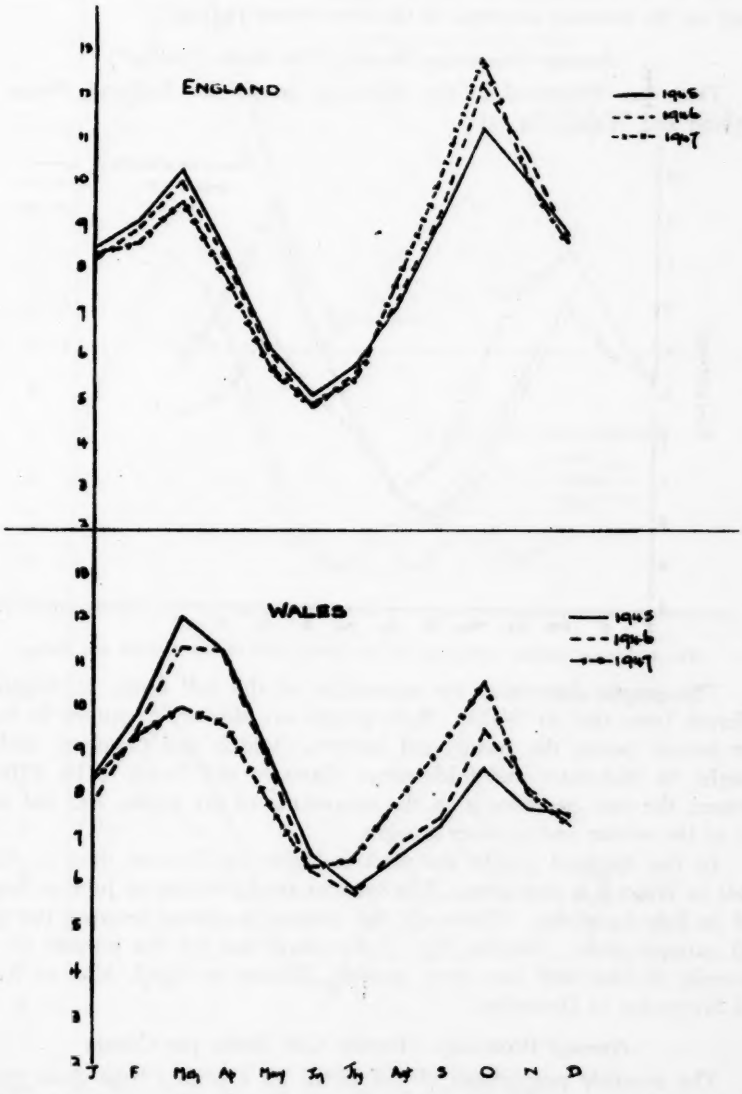


FIG. 1. Monthly percentages of calf births for the years 1945, 1946 and 1947 for England and Wales.

troughs in the graphs occur in June and January, and in July and December in Wales (except in 1947, when it is June and December).

In view of the slight annual changes, the discussion on the percentage is based on the monthly averages of the three years 1945-47.

Average Percentage Monthly Calf Births (1945-47)

These are illustrated in the following graphs for England, Wales and England and Wales (Fig. 2):—

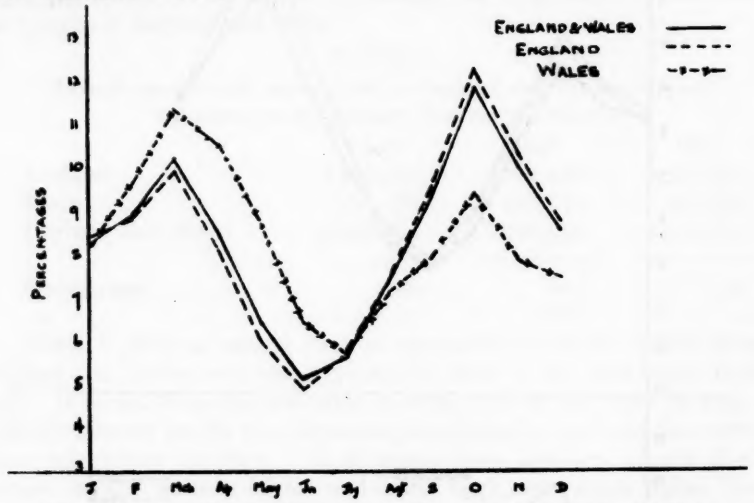


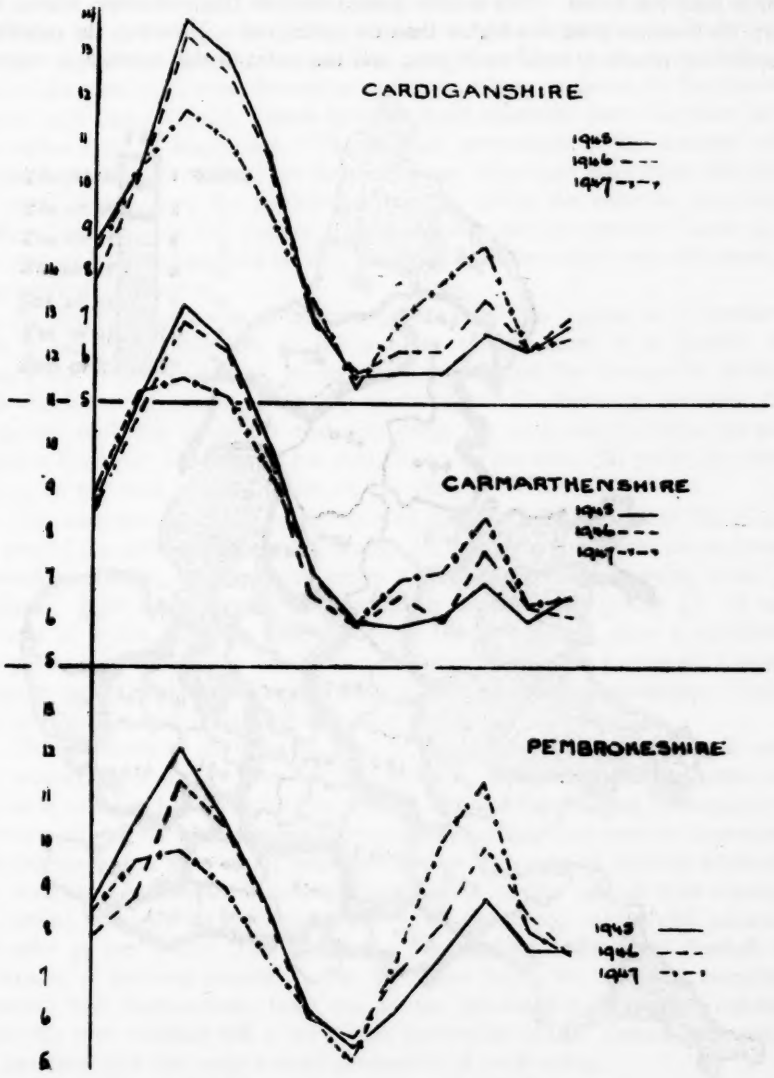
FIG. 2. Average monthly percentages of calf births (1945-47) for England and Wales.

The graphs show that the seasonality of the calf births in England is different from that in Wales. Both graphs are similar in pattern in having two annual peaks, the spring and autumn (March and October), and two troughs, in midwinter and midsummer (January and June). The difference between the two countries is in the magnitude of the peaks, and not in the size of the winter and summer troughs.

In the England graphs the peak is higher in October than in March, while in Wales it is vice versa. The summer trough occurs in June in England and in July in Wales. Obviously, the balance is always between the spring and autumn peaks. Graphs (Fig. 3) also show that for this purpose the year naturally divides itself into three periods, January to April, May to August, and September to December.

Average Percentage Monthly Calf Births per County

The monthly percentages of calf births on a county basis show changes from year to year, with a general tendency to increase the autumn percentages at the expense of the spring figures. The following graphs illustrate this tendency in the three counties in West Wales, viz., Cardiganshire, Carmarthenshire and Pembrokeshire, for each of the three years:—



Month of Conception	Ap.	May	Ju	Jl	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
Month of Birth	Jan	Feb	Mar	Apl	May	Ju	Jl	Aug	Sept	Oct	Nov	Dec

FIG. 3. Monthly percentages of calf births for the years 1945, 1946 and 1947, for three counties in Wales

The graphs show that the autumn peak has gradually risen, whilst the March peak has fallen. This is most pronounced in Pembrokeshire, where, by 1947, the autumn peak was higher than the spring one. However, the monthly changes are relatively small each year, and the order of the counties in respect

FIG. 4. County map of England and Wales showing the average percentages of calf births (1945-47) for the autumn months (September-December).

of autumn calvings has remained the same. As shown by Phillips and Davies (1949a), Pembrokeshire is in a favourable position to develop higher rates of autumn calvings.

The map (Fig. 4) illustrates the counties that belong to each group :—

It has previously been shown by Phillips and Davies (1949), and Phillips, Davies and Brown (1949), that the critical differences in the seasonality of the calf births are to be found in the four autumn months, September to December, for the reason that these correspond to conceptions during the most difficult time of the year, viz., from December to March, when, as shown by Hammond (1927) and Laing (1945), œstrus in cows is of relatively short duration and the œstrus cycle is lengthened. The average percentages of the autumn calf births (September-December) for the three years 1945-1947 have been obtained for each county, and the percentages used to group the counties according to their behaviour in this respect. These autumn percentages vary from 52.6 per cent in Buckinghamshire to 16.5 per cent in Radnorshire, with all manner of gradations in between.

By dividing the series of autumn percentages into groups in accordance with 5 per cent differences in the autumn calving rates, it is possible to classify the counties into five groups for England and five groups for Wales, with the following ranges of autumn percentages: (i) Above 45 per cent, (ii) 40-45 per cent, (iii) 35-40 per cent, (iv) 30-35 per cent, and (v) below 30 per cent, for England; (i) above 40 per cent, (ii) 35-40 per cent, (iii) 30-35 per cent, (iv) 25-30 per cent, and (v) below 25 per cent, for Wales.

The map shows that the major area of England falls into group (ii), 40-45 per cent of the calf births occurring during the four autumn months (September-December). These, together with group (i), are the intensive dairying areas of England. With the exception of Caernarvon and Anglesey (group (i)), all the counties of Wales, together with the Welsh border counties, show a relatively low percentage of autumn calf births; the same is true for Cornwall, Devon, Somerset and Cumberland on the west, as well as Kent, Lincolnshire, North Riding, Durham and Northumberland on the east.

Other sources of information (e.g., calf sale data, Ministry of Food, and the proportion of male calves reared—Ministry Returns) show that some of the above counties have remained important rearing counties, and, consequently, have not catered for high autumn calvings, whilst others have become important dairying areas, but have so far failed to develop high rates of autumn calvings. For example, Lincolnshire is an important rearing county (30 per cent autumn calf births), and only the dairying areas in it sell the surplus calves (with autumn calf sales 49 per cent). This shows that Lincolnshire could equal Norfolk if it became a dairying county. On the other hand two dairying counties, Somerset and Carmarthen, have not so far obtained high autumn calving rates; the two counties sell a very high proportion of the annual calf crops (66 per cent) and rear only a small proportion of male calves.

The map confirms the previous findings of Phillips and Davies (1949) that Cardiganshire and Carmarthenshire are regions with low autumn calvings.

The various county groupings have been averaged according to their monthly percentage calf births, and these are illustrated in the following graphs (Fig. 5):—

All the graphs are alike in general pattern, showing for each group the

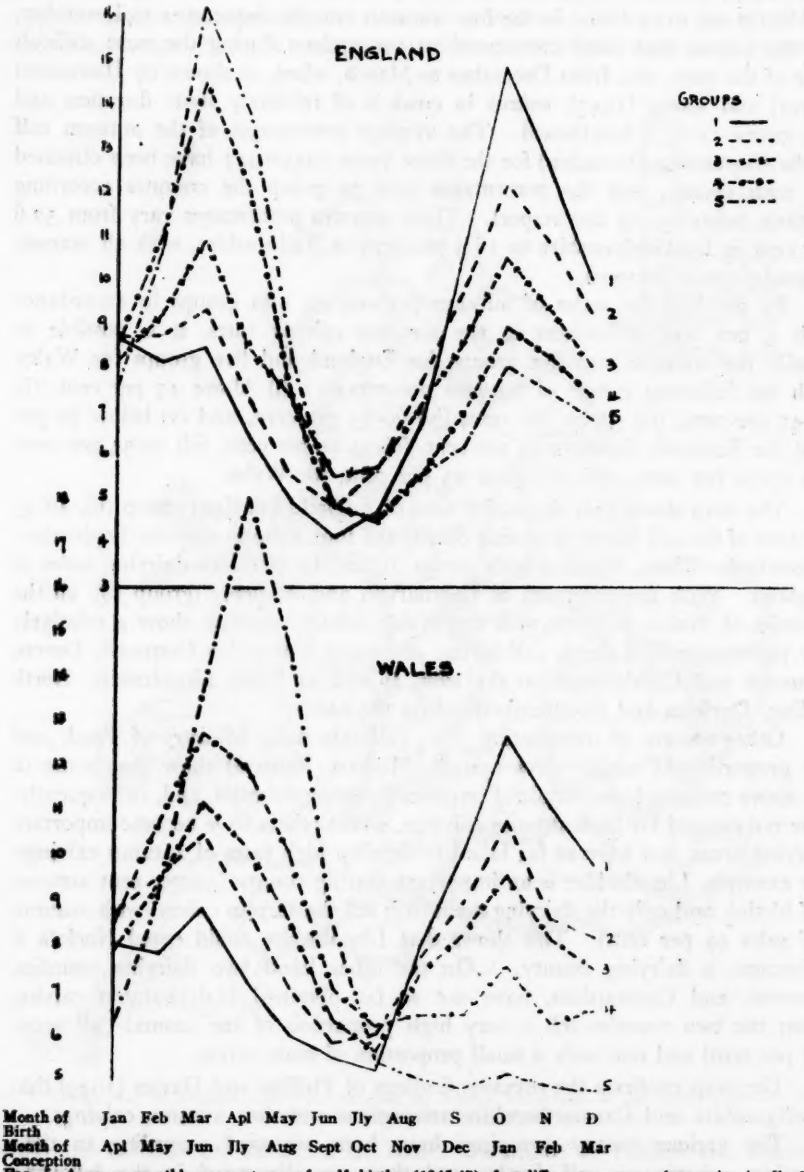


FIG. 5. Average monthly percentages of calf births (1945-47) for different groups of counties in England and in Wales.

two peaks (March-October) in different degrees, with approximately the same troughs. However, the differences between the groups show that where there is a high spring peak there is a low autumn peak, and vice versa. These two peaks invariably balance one another, and both occur in all the counties in March and October, respectively, except in Wales, group (v), where the spring peak occurs in April. The intervals between the two peaks are seven months, from March to October, and five months, from October to March.

In the Wales graphs there is practically no indication of an autumn peak in group (v), and only a moderate one in group (iv).

The midsummer trough is very well defined in all the graphs, but there is slightly more variability in the midwinter trough.

Quarterly Graphs

The following graphs (Fig. 6), based on the quarterly percentage of the calf births, illustrate the differences between the various groups of counties in England and Wales, and indicate how group (i), with a high percentage of calf births in the autumn quarter (September-November), gradually changes in groups (iv) and (v), with high percentages of spring (March-May) calf births :—

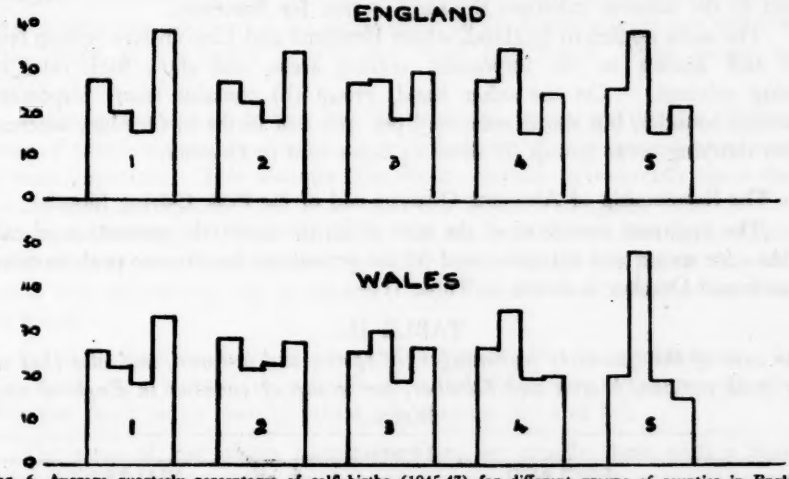


FIG. 6. Average quarterly percentages of calf births (1945-47) for different groups of counties in England and in Wales.

Month of Conception

The graphs in Fig 5. have also been used to indicate the months of conception corresponding to the months of birth, and they show that, with the exception of group (v) (Wales), the two periods of high service activity occur from May to July in early summer and December to February in winter (peaks in June and January), whilst the apparently much less active periods are from September to November in the autumn and February to April in spring, with the lowest rates in October and April.

Whether these active and inactive service periods correspond to a natural

seasonality of œstrus in cows, or whether the planning of the services is entirely the result of husbandry methods, is not known, but it is realised that the most difficult period of the year for œstrus to develop in cows and heifers is that from December to April, with March and April the most difficult of all, although in group (i) counties there appears to be no difficulty in this respect.

The graphs show that there are many counties with similar high rates of autumn calvings, and therefore of winter conceptions, whilst others show a considerably lower figure, and some show very moderate or slight rates of autumn calvings. This seems to indicate that there are factors other than husbandry influencing the winter development of œstrus. (The A.I. returns (MMB) show that there are only slight differences in seasonal conception rates.)

It has been suggested that these influences are climatic in origin.

The planning of the calvings must be closely linked with the system of farming, because invariably the rearing counties, e.g., group (v) (Wales—Brecon and Radnor), show a high rate of spring calvings, whilst groups (i) and (ii) (England) are important dairying areas with a high rate of autumn calvings. On the other hand, group (iv) (Wales—Carmarthen and Cardigan) are now important dairying counties, and have so far failed to make a material improvement in the autumn calvings; the same is true for Somerset.

The same applies to England, where Hereford and Lincolnshire (group (vi)) are still known to be important rearing areas, and show high rates of spring calvings. On the other hand, group (ii) contains many important dairying counties, but shows only 10.5 per cent calf births in October, whereas other dairying areas (group (i)) show 14.8 per cent in October.

The Relationship of Alternate Quarters and of the Peak Calving Months

The apparent constancy of the sum of (a) the quarterly percentage of calf births—for spring and autumn—and (b) the percentage for the two peak months, March and October is shown in Table II:—

TABLE II.

The sum of the quarterly percentages for spring and autumn, and also that of the peak months, March and October, per group of counties in England and Wales.

Group.	ENGLAND.		WALES.	
	Sum of the percentage quarterly calvings. Mar. to May and Sept. to Nov. %	Sum of the percentage calvings in the peak months. March and October. %	Sum of the percentage quarterly calvings. Mar. to May and Sept. to Nov.	Sum of the percentage calvings in peak months. Mar. and Oct. %
(i) ...	57.8	23.2	55.7	21.5
(ii) ...	55.1	21.6	54.2	21.1
(iii) ...	56.1	21.5	56.0	20.6
(iv) ...	56.0	23.4	54.8	20.3
(v) ...	59.8	24.3	60.8	18.8
Average ...	56.0	22.1	55.6	20.7

The table shows that nearly 55 per cent of the calf births occur during the spring (March to May) and autumn (September to November) quarters, and that 20-22 per cent of the annual total occur during the two peak months of March and October.

Discussion

The seasonality of the calf births in the various counties of England and Wales shows two interesting features:—

(i) The general pattern of the annual distribution of calf births is always the same, showing two main peaks in March and October, and two troughs in June-July and December-January.

(ii) Whereas the midsummer, or June-July, and midwinter, or December-January, troughs show but slight differences between the various counties, those between the peaks show very pronounced variations between them.

There are many factors to account for the similarity of the troughs and the variations in the peaks. The obvious suggestion is that the seasonal distribution of calf births is due to husbandry methods, and this assumes that the whole procedure is in the control of the owner. This simple answer hardly bears examination, in view of the gradualness of the changes from one extreme to the other, as was found in both the West and North Wales peninsulas (Phillips *et al.*, 1949a).

Another suggestion is that the variations in space are due to climatic factors of which temperature and average daily hours of winter sunshine appear the most important. This assumes that direct sunshine acts directly upon the animals, and consequently the areas with low winter conception rates receive inadequate amounts of winter sunshine. It has been shown that light affects reproduction in small animals, and recently Yeates (1947) has shown that the same is true with sheep, and Burkhardt (1947) has also had a similar response with mares.

In all probability, both climate and husbandry act in combination. In some areas, e.g., groups (i) and (ii), the husbandry can overcome climatic difficulties much better than in others, e.g., groups (iii) and (iv).

The areas of low winter conception rates are usually those with a high annual rainfall, consequently, the harvested crops of hay and corn are poorer in quality, particularly in protein, minerals and carotene and vitamin contents, with the result that the nutritional level of the animals in late winter is unsatisfactory.

This variation between areas in climatic conditions may thus account for the differences during winter in the extent of œstrus in cattle in various parts of the country.

The similarity of the annual graphs with their lowest troughs in June and July, coinciding with conceptions in September-October, seem to imply husbandry influences only. Maiden heifers come into heat at this time of the

year, and farmers in past years made a practice of turning out the bulls with the heifers during this period.

On the other hand, the husbandry system may be a reflection of the nutritional and environmental conditions, and what is described as husbandry is the practical adaptation of a system which is determined by climatic conditions. Thus, cows that have been starved of œstrogenic substances during late winter receive ample supplies in the fresh spring grass during April and May, and, consequently, there is the peak service rate in June. Later in the grazing season there may be an overdosage of œstrogenic substances in the body with the regular consumption of summer grass. This would interfere with normal œstrus in a similar manner to the subterranean clover effect in Australia, consequently, anœstrus or temporary infertility would develop until the end of the summer grazing period. When, however, the cows get on to the winter food, the surplus œstrogen is gradually eliminated until it becomes similar in level to that of June, and, consequently, there is again a peak service rate in January. The gradualness of the disappearance of œstrogenic substances in the autumn would thus account for the higher and less regular December-January trough in calf births compared with the more rapid accumulation of the œstrogens in summer, resulting after the peak services in June in a sharp drop to a low rate of calf births in June and July.

Some evidence of the œstrogenic properties of grass is already available (Folley (1948) and Evans (1949)), and it is only further biochemical studies of pasture plants that will give the complete answer to these questions.

Summary

The calf births, as recorded in the quarterly returns of the Ministry, have been examined and the annual calf crop determined for England and Wales for the period June, 1944, to June, 1948.

(1) The seasonality of the percentage calf births indicate that the autumn calving rate varies in different parts of the country.

(2) The counties of England and Wales can be grouped in accordance with the similarity of their autumn calf birth rates.

(3) The patterns of the annual monthly distribution of the calf births have been made for various groups of counties.

(4) The similarity of the various patterns indicate that factors other than control by the farmer influence the results.

(5) The sums of the autumn and spring peak percentages have been shown to vary within narrow limits of 20-22 per cent, and that the two quarters, March to May and September to November, contribute 55-56 per cent of the annual calf births.

(6) The suggestion is made that the varying amounts and the balance of œstrogenic substances in the diet at different times of the year influence the development of œstrus in cattle, and, consequently, the optimum amounts of œstrogen coincide with periods of maximum service activity, and vice versa.

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THE PHARYNGEAL CAVITY OF THE CAMEL

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Introduction

THE pharyngeal cavities of many domesticated animals have been described by previous workers, yet that of the camel is lacking in details.

Chauveau (1891) states that the pharynx of the camel is divided into two compartments by a transverse mucous fold detached from the posterior wall.

Lesbre (1906) describes the pharynx as being a long, narrow cavity, containing numerous glands, in the posterior cul-de-sac.

The object of this paper is to give a more detailed account of the pharyngeal cavity of the camel.

Material and Method

Material was obtained from the slaughterhouse at Cairo. Ten heads of both mature male and female Sudanese camels were received. They were separated from the carcasses just behind the axis. The skin was intact. The specimens were injected with 10 per cent formalin solution. In addition, the pharynx was examined in several carcasses in the slaughterhouse.

The Pharynx of the Camel

Examination of the cavity revealed that it was narrow transversely, but it was very extensive in both the dorsoventral and anteroposterior directions. Dorsally and laterally, it was surrounded by a thick layer of fat.

Internally, unlike the case in other domesticated animals, the posterior division of the pharynx was divided into two parts—dorsal and ventral—by a thick, horizontal, shelf-like prominence of the mucous membrane, formed by the

insertion of a muscle, which will be described later, and which is not present in the other domesticated animals. This shelf-like prominence forms, with the pharyngeal surface of the soft palate, a narrow channel, through which the dorsal part and the nasal cavity communicate with the ventral part. The latter appeared to represent the posterior pharyngeal division of equines.

The piriform recess was extremely deep, and formed, with the lower part of the ventral division, a wide space, in which the larynx stood in a spout-like manner. This was caused by the two halves of the pharyngopalatine arch being united on a higher level than that of the aditus œsophagi. The dorsal part was a deep cavity, extending below the auditory tube and above the before-mentioned muscle and in touch with the base of the skull and the ventral straight muscles of the head.

The auditory tube opened by a twisted, funnel-shaped infundibulum in the anterior part of that division.

This dorsal division was in a straight line with the nasal cavity, and both communicated with the ventral part through the before-mentioned channel.

The anterior division of the pharynx was deeply depressed behind the root of the tongue, due to the vertical disposition of the latter.

The glosso-epiglottic fold was obviously prominent, due to the enormous development of the hyo-epiglotticus muscle, causing two deep, longitudinal recesses on both sides of the fold.

Numerous glands were present in both the anterior division and the ventral part of the posterior division, as well as on the shelf-like prominence. The glands were so numerous that they produced crypts and wrinkling of the mucous membrane.

The colour of the mucous membrane of the pharynx varied; it was usually pale yellow, whitish yellow, or greyish.

The Muscles of the Pharynx

The palatopharyngeas was not so well developed as in equines. Its fibres were directed backwards in a straight line.

The pterygopharyngeas was a feeble muscle, and its fibres were directed downwards.

The stylopharyngeas was thick and broad, but shorter than that of equines.

The hyopharyngeas.—The *keratopharyngeas* was constantly present. The *chondropharyngeas* was thick and straight.

The cricopharyngeas and thyropharyngeas muscles were thick and confounded.

The most notable feature observed in the camel's pharynx was the presence of a well-deveoped muscle which is absent in other domesticated animals—the muscle was termed the atlantopharyngeal muscle. In all specimens dissected, and in several heads in the slaughter-house, the muscle was constantly present in both male and female subjects. It took origin from the ventral surface of

FIG. I.: A—The atlantopharyngeal muscle. W—Wing of the atlas. D—Dorsal division of the posterior part of the pharynx. V—Ventral part of the same. R—The prominent ridge between the two divisions of the same. C—The narrow channel through which the nasal cavity and the dorsal part communicate with the ventral part. X—Epiglottis. O—Oral part of the soft palate. T—Palatine tonsils in deep tonsillar sinus. A"—Anterior part of the pharynx. P—Glossopalatine arch or anterior pillars of the soft palate.
Note the presence of many crypts, due to the enormous number of the glands found in the division and the ventral part of the posterior division.

(Article by M. A. F. Tayeb)

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the body of the atlas by a rounded tendon, and its fibres diverged downwards and forwards, to be inserted into the dorsal wall of the pharynx, forming the horizontal, prominent, shelf-like ridge of the mucous membrane mentioned before (the ventral tubercle of the atlas was absent in that animal).

In the specimens examined there was no evidence of a gutteral pouch.

Summary

The pharyngeal cavity of the camel was studied in ten injected heads of both male and female Sudanese camels obtained from the Cairo slaughterhouse. In addition, the pharynx was studied in several heads in the slaughterhouse. The results of these studies were as follows:—

(1) The cavity was narrow transversely, but very extensive in the dorso-ventral and the anteroposterior directions, respectively.

(2) The posterior division of the cavity was divided into two parts by a horizontal, shelf-like prominence of the mucous membrane.

(3) The presence of a well-developed muscle—the atlantopharyngeal—not present in other domesticated animals.

(4) The absence of the gutteral pouch.

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CLINICAL ARTICLES

THEOBROMINE POISONING IN DUCKS
Due to the Feeding of Cacao Waste Products

By O. V. GUNNING, D.V.M., F.R.C.V.S.

THE owner had a flock of 35 laying ducks (Aylesburys and Khaki Campbells).

One evening, a bird was found dead. On the following morning one hen, and during the course of the day three more ducks died. When the owner's wife went to feed them she saw two of these collapse and die.

On our examination, one of the remaining ducks appeared sickly, lying by itself, and when disturbed appeared to have no use in its limbs. Post-mortem examination on this duck showed a degenerated liver.

It was ascertained the birds had been fed whole oats, together with a mixture of crushed oats, bran and a cocoa-like substance. The owner had purchased the latter on the recommendation of a friend as an excellent supplementary ration for both pigs and poultry.

A sample of this food was forwarded, together with a duck and a hen, to the Institute of Animal Pathology, Cambridge, which reported as follows:—

"Post-mortem examinations have been performed on the duck and fowl which you sent here. There was no pathogenic lesion of contagious disease and cultures made from the organs were sterile. The foodstuff you sent was a cacao product. The absence of lesions and the symptoms were consistent with a diagnosis of theobromine poisoning."

Quoting from an article on "The Poisoning of Livestock by Cacao Products," Blakemore and Shearer state:—

"During 1941, several outbreaks of poisoning amongst pigs and poultry were brought to our notice, and in each case it was found that the losses followed the feeding of meals containing cacao products. In fowls the condition was characterised by sudden death within 48 hours after feeding the food, and in certain instances the death rate was considerable. The birds which did not succumb appeared healthy, but the owners stated that the birds consumed an increased amount of water. On two farms the feeding of food containing cacao products to pigs was followed by inappetence, but the condition was transitory and the animals recovered when the food was changed."

The following are their conclusions:—

"There would appear to be ample evidence that cacao husks and meal are liable to have toxic effect on animals when fed in quantity. Horses, swine and poultry are evidently particularly susceptible. The toxic effects produced by feeding cacao shells or meal are due to the presence of theobromine. Moreover, these products do not seem very acceptable to animals, and are evidently not taken very well when first mixed with the food. Since theobromine is present in varying amounts in cacao products, depending on previous treatment, etc., it is suggested that neither cacao husks nor meal should be fed to farm animals without previous analysis, and in any case should not be given in quantity."

Acknowledgment

My thanks are due to the Institute of Animal Pathology, Cambridge, for invaluable assistance.

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SUSPECTED POTATO POISONING IN A MARE, With Fatal Termination

By O. V. GUNNING, D.V.M., F.R.C.V.S.

On the evening of May 27, a call was received to attend a skewbald children's riding pony, four years old and standing about 14.2 h.h.

There was a history of the pony having been off feed the previous day, and it had probably been suffering from abdominal pain for some time. The owner had no knowledge of horses; the pony had been on an indifferent pasture and had, in addition, been receiving some poor hay and a small allowance of

corn. The pony was in fair condition. There was a further history, however, that prior to the onset of symptoms the previous day the gardener had given the pony a good feed of "greened" sprouted potatoes, which she had devoured with avidity.

The pony was tucked up and showed fairly continuous sub-actute abdominal pain. There was tympany at both flanks and peristalsis appeared practically dead. The pulse rate was about 80 and the eye was injected and icteric. A further unusual symptom was that the pony would stand with her forelegs crossed.

The tube was passed and a pint of mineral oil administered, together with turpentine and æther meth. One c.c. of carbamycholine was given hypodermically.

On the following morning the animal showed a remarkable improvement; peristalsis was audible on both sides; the pony was much brighter and practically free of pain. It drank freely. In an effort not to do the wrong thing, an enema was the only treatment given. It was returned clear, but brought with it a small quantity of flatus.

Seen the same evening, the pony was definitely worse. The flanks were again tympanitic, peristalsis was inaudible, and there was an almost imperceptible running down pulse. The pony died shortly after.

Post-mortem examination showed the mesentery to be badly inflamed. The stomach mucous membrane was acutely inflamed, and also the small bowel leading from it, which contained bloody fluid. The liver showed marked fatty degeneration. There were no signs of twist, bowel displacement or stoppage, and the intestines were not unduly full.

H. C. Long states that: "The potato (*Solanum tuberosum L.*) contains an alkaloid, solanine, in various proportions in the green parts, and to some extent in "greened" tubers. In general, the tubers as commonly used may be eaten with impunity, but there are records of injury to man by eating 'greened' tubers. Henslow says that accidents with animals are not at all uncommon, and cattle have suffered most. Chesnut and Wilcox (U.S.A.) mention the loss of six pigs due to eating uncooked sprouted potatoes. Macfadyean has shown that old sprouted potatoes, even after boiling, are deadly poison to horses. In 1896, eleven horses died from eating, in most instances, small quantities of spoiled and sprouted 'chat' potatoes, and two test horses fed on the potatoes died."

REFERENCE

"Poisonous Plants on the Farm": H. C. Long.

CORRESPONDENCE

THE CONTROL OF RINDERPEST

Dear Sir,

The July, 1949, number of THE BRITISH VETERINARY JOURNAL contains an interesting article by Dr. J. T. Edwards on the use of caprinized virus in the control of rinderpest. This article lays stress on a number of points which are recognised by veterinary research and administrative workers in the majority of countries in which rinderpest is still an important day-to-day problem; but which, owing to pressure of work and difficulties over publication during and immediately after the war, have not received the publicity that they deserve.

The general theme of Dr. Edward's paper is that, in undeveloped countries, the most satisfactory method of controlling rinderpest is to raise the level of herd immunity by active immunisation. This indeed has been the policy adopted by the Kenya Veterinary Department for the last 25 years. With expensive methods of immunisation, such as the serum simultaneous method, a high level of herd immunity could not be achieved. Nevertheless an effort was made to give durable immunity each year to as many cattle as funds and personnel permitted. With the advent of inactivated vaccine a safer method of protecting the more valuable, highly susceptible, introduced breeds became available; but, except under special circumstances and in limited areas, this method was never used on indigenous, zebu cattle. The elaboration of Kabete attenuated goat virus (KAG) made possible the rapid immunisation of whole cattle populations, and within a matter of two or three years the rinderpest picture changed. Whereas all African areas had been in perpetual quarantine because of enzootic rinderpest, the total number of (unconfirmed) outbreaks in the whole country south of the Northern Frontier Province fell to about five per annum, these outbreaks being mostly in calves. In achieving this result it was estimated that the herd immunity had been raised to a figure somewhat in excess of 90 per cent.

A second point of importance is the difference in behaviour between bovine and caprinized strains in cattle receiving simultaneously a dose of serum. Providing that a reasonable dose of fresh bovine virus is given, serum will not block the reaction to the extent that a permanent immunity is not conferred. With a caprinized virus, however, even small doses of serum are liable to prevent a reaction and a number of susceptible cattle is always left after an attempt to immunise by the simultaneous method using caprinized virus. Unfortunately, the method of protecting the more susceptible breeds of cattle suggested by Dr. Edwards, namely, by giving a dose of a moderately caprinized strain of virus 12 days after a dose of inactivated vaccine, has not been found satisfactory in practice in Kenya. It would appear that even small doses of inactivated vaccine will render many cattle non-receptive to the less invasive virus. Little useful purpose would be served by repeating the virus a fortnight later. Protection by the vaccine is then likely to be greater.

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A third point made by Dr. Edwards, which is now probably a matter of common knowledge, is the danger of rinderpest spreading in cattle not fully protected by inactivated vaccine. In cattle, the vaccine immunity of which is beginning to wane, the diagnosis of rinderpest may only be possible by inoculation.

Still another point is the fact that, on repeated passage in goats, the attacking power of the virus for cattle becomes reduced. One passage in cattle will usually restore attacking power sufficiently, and by experience one learns when a bovine passage should be interpolated.

Dr. Edward's paper also contains a number of statements at variance with the writer's twenty years of close experience with rinderpest and which, if allowed to pass unchallenged, may be quoted as undisputed facts. Firstly, there is the question of the ease with which the disease spreads. It has long been recognised amongst British workers that in foot-and-mouth disease some strains of virus spread much more readily than do others, and that this ability to spread is a strain character quite independent of virulence or type. Similarly in rinderpest there is a quite remarkable variation between strains in their "contagiousness." In general, laboratory strains that have been maintained for many years by "needle" passage are not very contagious: spread by contact will not usually occur between cattle kept in adjacent boxes. The most contagious strain which the writer has encountered was, however, an Indian caprinzed strain, and it would appear that in rinderpest, as in foot-and-mouth disease, contagiousness is a character independent of virulence. Although rinderpest never spreads with the facility of the more contagious foot-and-mouth disease strains, the statement that it rarely "occurs except through a fairly close contact with animals that are actually suffering from the disease" is liable to give a dangerously incorrect impression.

Another point that must be mentioned concerns the value of inactivated vaccine in cattle of high susceptibility. Lalaune's paper is not available for reference; but our experience in Kenya showed that the effects of a formalised vaccine were greater, the higher the susceptibility of the stock on which it was used. In this connection it may be mentioned that the simultaneous inoculation of hyperimmune serum with inactivated vaccine causes the development of the vaccine immunity to be delayed until after the effects of the serum have disappeared.

On the practical aspect of the use of caprinized virus in the field Dr. Edward's views differ widely from the writer's. The basis of our difference may probably be contained in his statement that all the material necessary to inoculate the cattle population of Egypt could have been obtained from the spleen of a single selected British goat. Even with the most efficient desiccation procedure one cannot obtain a multiplication of virus during the process. With the cryochem method used at Kabete the titre of virus on a fresh tissue basis before drying was roughly that found on a dry matter basis after drying and ran about 1 : 50,000-1 : 100,000. In theory, therefore, 10 g. of spleen might

immunise one million head. In practice, however, it is necessary to allow for deterioration of titre during transport and storage under field conditions and, in view of the variations in receptivity amongst the cattle to be inoculated, *to ensure that each receives a sufficient number of m.i.d. to provoke a response.* For these reasons, in Kenya, one gramme of dried spleen was allowed for the inoculation of 200-250 head. The East African goat is a small beast, and experience over many years showed that in computing the number of goats required to produce a given number of doses, it was advisable to reckon no more than 1,000 doses per goat. Even at this figure caprinized virus must be one of the cheapest biological products that has ever been prepared.

It is most unfortunate that Dr. Edwards does not given the dose of virus employed in the experiment that he describes on page 240, and that he did not test the immunity of this batch of animals two to four weeks after inoculation. To one who has studied many hundreds of charts of animals inoculated with KAG virus, this experiment can be interpreted in one way only, the dose of virus was a border-line dose and the high percentage of non-reactors and so-called "very mild reactors" is due to the fact that these animals received less than an infecting dose. This is not only the most likely explanation of the failure of susceptible animals to react to any inoculation, but it is strongly supported by the lateness and general appearance of the reactions illustrated on page 243. The writer would interpret none of the four cattle classed as (b) degree reactors on page 247 as reactors, and would have expected them to break down had their immunity been challenged with bovine virus. Similarly the charts of working oxen on page 248 are most unsatisfactory.

Although a small percentage of susceptible cattle do appear to gain immunity from the inoculation of KAG virus without showing a thermal response, even in East Africa where the full susceptibility of cattle is often in doubt, we looked upon such a phenomenon with suspicion. Certainly we believed that in order to ensure a durable immunity in a batch of susceptible cattle we should see thermal reactions in over 90 per cent, and in the case of results similar to those recorded by Dr. Edwards we should have insisted upon re-inoculation.

Yours faithfully,

J. RICHARD HUDSON.

ABSTRACTS OF CURRENT LITERATURE

ROGERS, W. P., and LAZARUS, M. (1948).—Glycolysis and Related Phosphorus Metabolism in Parasitic Nematodes. *Parasitology*, Vol. 39, Nos. 3 and 4, pp. 302-313.

This has been studied in some detail in the nematodes Neoaplectana glaseri, Ascaridia galli, Nematodirus spp. and Nippostrongylus muris; the R.Q. of whole N. glaseri rose from 0.56 to 1.10 when glucose was added to the medium, but the respiration of the other parasites was largely unaffected. The subject was further studied on extracts from various tissues of the parasites, and it was concluded that carbohydrate fermentation as far as lactate in nematode parasites was similar to that found in yeast and mammalian muscle. Energy was transferred by means of high-energy phosphate bonds.

ROGERS, W. P., and LAZARUS, M. (1948).—The Uptake and Radioactive Phosphorus from Host Tissues and Fluids by Nematode Parasites. *Parasitology*, Vol. 39, Nos. 3 and 4, pp. 245-250.

The uptake and distribution of radioactive phosphorus within the tissues of Ascaris lumbricoides incubated at 37 deg. C. in saline buffered at *pH* 6.8 and containing approximately 2.5 microcuries of P 32/10 ml., was examined by means of the autoradiograph technique. The intestine, uterus and perienteric fluid were found to have a high phosphorus content compared with the corresponding organs and blood of mammals; the muscle, however, contained little more than half that found in mammalian muscle. The phosphorus appeared to be absorbed largely through the intestine.

Nippostrongylus muris in the intestine of the rat rapidly took up radioactive phosphorus which had been injected into the host intramuscularly, but radioactivity was less in the parasites than in the host intestine, when the host was dosed with phosphorus.

Ascardia galli showed no radioactivity when the host was injected, but took it up rapidly when the host was dosed with radioactive phosphorus. It is suggested that the different feeding habits of N. muris, which feeds on host tissues, and A. galli (on host gut contents) may have some relation to the efficacy of antihelminthics against them.

REVIEWS

THE YEAR BOOK, 1950. London: The Farmer and Stockbreeder. Price 7s. 6d. net.

"THE FARMER AND STOCKBREEDER" have sent us a copy of their Year Book which contains ten articles headed by a most interesting one by Prof. Sir James Scott Watson, Chief Scientific and Agricultural Adviser to the Ministry of Agriculture, entitled "The World Can Be Fed."

Another feature of this book is a section entitled "The Pedigree Year in Pictures," a beautifully produced collection of photographs of pedigree stock.

At the back of the book is a reference section of general and statistical information, and this and the voluminous advertisements alone make the Year Book a useful work of reference.

BRITAIN'S GREEN MANTLE, by A. G. Tansley. 144 photographs and 6 diagrams. London: George Allen & Unwin, Ltd. Price 18s.

THIS book is so admirably described by the "blurb" which the publisher prints on the dust cover, that we cannot do better than repeat it. "This book describes the different kinds of natural vegetation found in Britain—wood, downs and hill pasture, heaths and moorland, mountain and bog, fresh water, fen and sea coast—tracing the history of changes in the face of the country since the Great Ice Age and through historical times, and looking also to the fate of our natural vegetation in the future. It aims at providing a good deal of solid information about our native plant life and the agencies that influence it, but it is written so as to be intelligible to all, the very few technical terms used being clearly explained. All plants mentioned are given their English names when they have any, the botanical name being usually added."

For the veterinary surgeon there is little of direct interest in the account the author gives of our vegetation, but, nonetheless, the subject is one to which he should turn his consideration, seeing the increasingly great part played by modern agricultural science is in the control and development of the soil. Farm animals are the product of what they eat, and what they eat is what grows from the soil, and what is grown and how it is grown is the intimate concern of the veterinary surgeon. This book will therefore be found full of interest by every veterinary surgeon: it should be read in conjunction with that masterly book dealing with the integrated wholeness of the landscape, "The Earth's Face," by Ehrenfried Pfeiffer.

Publishers' Notices

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